A OPHTHALMIC METHODS EMPLOYED FOR THE RECOGNITION OF NERVE DISEASE.

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MOST IMPORTANT OPHTHALMIC METHODS

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RECOGNITION OF PERIPHERAL AND CENTRAL NERVE DISEASE.

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TO

S. WEIR MITCHELL, M.D., LL.D., HARVARD,

WHO WAS THE FIRST TO THOROUGHLY APPRECIATE BOTH THE THEORETICAL AND THE PRACTICAL BEARING OF EYE-STRAIN UPON CENTRAL AND PERIPHERAL NERVE-DISORDER, AND TO BRING THIS MOST IMPORTANT BRANCH OF SCIENTIFIC MEDICINE INTO EVERY-DAY THERAPEUTICS, THIS LITTLE WORK IS, BY PERMISSION,

DEDICATED

AS A TOKEN OF THE RESPECT AND ESTEEM IN WHICH HE IS HELD

BY THE WRITER.

A DESCRIPTION OF SOME OF THE MOST IMPORTANT OPHTHALMIC METHODS EMPLOYED FOR THE RECOGNITION OF PERIPHERAL AND CENTRAL NERVE DISEASE.

The methods for the determination of the ocular signs of general neuroses and related symptomatic local disorders divide themselves into four groupings. The first, by reason of the comparative anatomical simplicity of the structures to be studied and the ease of recognition of related physiological action, constitutes the most important and the most readily understood of all of the ophthalmic methods that are employed in the objective plans for the determination of the physical conditions of the sensory groupings of the visual apparatus. The second, which in reality is a direct sequence of the first, consists in the contrivances and plans that are intended for the recognition of the various subjective sensory symptoms of the apparatus. The third, the least complex and the easiest of comprehension of the entire grouping of procedures, is the series for the determination of the objective motor symptoms. The fourth, though in fact at times constituting the most important of all the clinical methods, consists in the plans that are necessary for evolving the existence, kind, and degree of the subjective

motor groupings.[1] Thus subdivided, the methods for research can be easily understood, and the significance of the findings can be readily realized. Not that any one plan can be relied upon to give proper answer as to the causal lesion: not that any single grouping of simple procedures is sufficient to vouchsafe an adequate diagnosis. Each form of relevant physiologic action and every variety of related anatomical structure must be carefully studied and conscientiously looked at *seriatim* by the aid of some of the most important and the best adapted clinical methods. This, done not only once, but repeatedly and at regular intervals from the very first suspicion of neural disorder, will, when carefully performed by competent observers, frequently afford much clinical data towards the correct and early diagnosis of grave nerve-disease that ofttimes may thus be checked by appropriate hygienic and therapeutic measures.

Objective Determination of Sensory Symptoms.

Taking the plan for the objective determination of the sensory groupings first, we are at once placed before the most important, the most comprehensible, and the most pretended of the procedures,—ophthalmoscopy.

[1] The topics in this monograph are so arranged that the reader may at a glance be able to group those methods of precision that pertain to the recognition of allied conditions, thus placing the entire subject-matter in a logical and definitive order, a plan that becomes eminently useful in the careful study of the various neuroses. Of course, every case should be submitted to a routine plan of examination.

Given a good instrument and a carefully-trained eye, the observer has an ample opportunity set before him in the vascular and the neural circles spread before his gaze to formulate correct opinions not only as to the character of local disease of the intra-ocular media and tunics, but as to the character of many general disorders that are prone to afford intra-ocular expression of their ravages.

For this purpose there are two methods. One is known as the direct or upright method, where the observer looks directly upon an upright image. The other is termed the indirect or inverted plan, where an aerial image or an indirect picture, which is both inverted and reversed, is seen. In the former, the observer, who should be upon a somewhat higher level than the patient, sits at the side and slightly in front of him. The source of illumination, which should be single and steady, is to be placed at the back and to one side of the patient, so that his eye is in shadow and that an angle of about fifteen to thirty degrees is formed between the patient's eye, the observer's eye, and the light. The observer should next so place his instrument before his own eye with the mirror partly facing both the patient's eye and the light in such a way that he can look directly through the sight-hole of the instrument into the pupil of the patient's eye. If this has been done correctly, the patient's pupil will, if clear, become almost uniformly red in appearance. The observer thus knows that he has illuminated the interior of the patient's eye, and that he has, in consequence, obtained the so-called red fundus-reflex. The increased power

of magnification of the apparent size of the fundal elements over the continental methods of ophthalmoscopic study by this method may, by proper contrivances,[1] as suggested to the writer by Dr. S. Weir Mitchell, be still more greatly enlarged, so as to examine almost microscopically any specially desired detail, thus rendering this method far better than the indirect plan.

To properly employ the direct method, the observer should first search for changes in the cornea. By employing a sixteen- to thirteen-diopter-strength lens in the instrument and gradually decreasing the focus of the lens to twelve-, ten-, and nine- diopter strengths for the anterior capsule, the cortex, nucleus, and the posterior capsule of the lens, most of the structures in the anterior segment of the eye can be successively studied. The lens-strength should then be weakened as the vitreous chamber is more and more deeply penetrated. As soon as the fundus is reached, the optic-nerve-head is the first portion to be sought for. This can be easily accomplished by following the course of one of the main retinal stems up to that portion of the eye-ground that appears like a pinkish-white gray plaque or disk. Found, its apparent size, measured in a number of diameters of one and a half millimetres each (which represents its real size), should next be noted. Its axis of greatest length as gauged from a horizontal zero, the comparative tints of its different quadrants, its irregularity of surface contour, the dis-

[1] The writer, at the suggestion of Dr. Mitchell several years ago, is at the present time perfecting such an instrument.

tinctness of its borders, and the degree of pigment absorption beyond its edges, should all be accurately recorded. In fact, any normal or abnormal condition, both neural and vascular, that may seem worthy of notice, should be carefully registered upon suitable blanks. The comparative sizes of the retinal vessels, the relative tint of the contained blood, the thickness of the channel-walls, their tortuosity and waviness, the widths of the light-streaks, and the visibility of the lymph-sheaths next demand attention. The appearance of the macular region with its contained yellow spot, the general tint of the fundus, the amount of absorption of pigment epithelium, the degrees of choroidal disturbance, the character of the general opacification of the retina,—especially any increase in the thickness and the visibility of its fibre-layer,—and the kind and amount of ametropia should be registered in every case. If to these—the ordinary variations in fundus-structure, which serve as the basis upon which to build, as it were, any pathological conditions—be added all gross changes as tersely and as clearly expressed as possible, this form of ophthalmoscopic record becomes, in due proportion to its degree of completeness and correctness, a valuable guide to both the general and the special student in neurology.

Should desire be had for a large field of vision in which accurate details are not necessary,—as, for instance, to obtain a general view of the appearance of the fundus, just as is so frequently done by weak objectives in topographical microscopy,—the other method may be employed, where, instead of directly approaching the patient's eye

with the ophthalmoscope and looking directly upon the fundus, the instrument is held at some forty-five to fifty centimetres away from the eye to be studied. By this plan, the details of the fundus are projected into the air as an inverted and reversed image. As so much of the eye-ground is given at a single glance by this plan, thus offering a better idea as to the exact location of pathological changes, it should always be employed by the special investigator.

To obtain the best results by the inverted method, there should be, as in the first plan, a single source of illumination. If desired, an incandescent loop of electricity of about sixteen to twenty candle-power, which, whilst not being too intense in illumination, closely simulates ordinary solar light, can, just as in the other method, be used.[1] The source of light should be so placed at the back and to one side of the patient that his eye is in shadow. An ordinary concave mirror ophthalmoscope is then to be held directly in front of the observer's eye, so that he can look through the sight-hole of the instrument. The observer should be seated at about fifty centimetres' distance in front of the eye to be examined. If a strong biconvex lens is held in the observer's other hand between the eye to be examined and the instrument, a small inverted and reversed aerial image of the details of a large area of the patient's fundus or any other portion of

[1] The writer prefers this illumination to the yellowish-red light by the burning of impure carbohydrogen compounds. Of course, however, this is a mere personal preference that the reader is not asked to coincide with.

the interior of the organ situated in the so-called ophthalmoscopic field, will be seen. By constantly changing the relative positions of the mirror and the lens with the light and the patient's eye, both the lateral extents and the antero-posterior portions of the ophthalmoscopic area can be successively searched for pathological change. If an enlarged field of illumination, though, of course, not so brilliantly an illuminated one, be desired, a plain mirror can be substituted for the concave one.

If the observer is able to sketch or to paint, much aid may be offered to him in the future conception of the ophthalmoscopic pictures by making either careful drawings upon prepared sheets, as in Haab's plates, which are composed of superimposed layers of chrome-yellow and cinnabar over sheets of a dull white ground, or pen-and-pencil sketches that are designative of the most important changes seen. To assist him in this, Tiffany's sketching blanks, which are ruled in proportionate size to the apparent magnification in the upright image, may often be useful. Bellarminoff's method—a mere modified revival of the old plans of orthoscopic study—of examining the fundus of the eye by pressing a piece of plain glass against a cocainized cornea so as to flatten that membrane and thus allow the details of the eye-ground to become visible, might under certain circumstances be of value where no better instrument of precision is at hand. Here, however, the details are quite minute in size,—a difficulty, nevertheless, that might be lessened by the employment of a magnifying lens in front of the sheet of glass.

One of the most important methods for the objective detection of changes in the sensory portions of the visual apparatus, is that known as oblique, lateral, or focal illumination. In connection with ophthalmoscopy, it lays bare, with the exception of a small ciliary zone, almost the entire internal tunics and refracting media of the eye. With it, the appearance of the entire anterior external segment of the eye, the cornea, the aqueous, the iris, almost all of the lens, and much of the forward part of the vitreous can be brilliantly illuminated and magnified. Irritation signs of neural and vascular types, such as epithelial thickenings, swellings, and venous and arterial engorgements, atrophic areas, as shown by denudations of epithelium and blanching and discoloration of tissue; and evidences of old inflammation, as recognized by vascular engorgements; deposits of false material and thickenings and thinnings of normal structure; all can be made evident and are readily differentiated by this method.

One of two plans may be pursued. The first, which is the less preferred, is that by concentrating diffuse daylight upon the affected portion of the organ. The second is that which is accomplished by bringing some of the rays from an artificial illuminant to a focus upon the area that is desired to be the more plainly seen. To do either of these successfully, a strong planoconvex or biconvex lens is held at or about its focal distance from the eye in such a position that the impinging light rays may be concentrated upon the part that is desired to be studied. A second lens of about the same strength or much

stronger, as, for instance, the so-called "corneal loupe," can then be held at right angles to the illuminating lens in such a position that the observer can look through it at the underlying ocular tissues. If properly done, a highly-magnified and brilliantly-illuminated image of the part looked at will be obtained.

An excellent plan to determine the existence and the exact position of any area of denudation of the deeper-lying conjunctival and corneal tissues can be taken advantage of by the employment of a drop or two of a 2-per-cent. solution of a sodium or potassium salt of fluorescin. When employed, care should be taken to wash the excess away by some distilled water. If this be done properly, it will be seen that the drug has the power to stain any denuded surface of corneal tissue a deep greenish yellow, whilst it causes breaks in the bulbar and tarsal conjunctivæ to become yellow in appearance.

Where gross lesions about the orbit, as, for instance, when neoplastic formations in the maxillary antra are suspected, advantage might be taken of the recent proposition of transillumination by electric light. A guarded loop of about five to ten candle-power can be carried far back and up into the nasal fossa. When in this position, the loop can be rendered incandescent. If the procedure be properly done, a coarse configuration of the bony cavities can be well made out and the globes may become partly translucent. In this experiment, the pupil frequently remains dilated and emits a red glare known as Davidson's sign. If there be any degree of lessening of luminous perception, Gavel's sign is said to be present.

In some cases, it may be of value to make a spectroscopic examination of the interior of the eye. This, it is said, can be done by interposing a spectroscope in the path of the return rays from an ordinary ophthalmoscope into the observer's eye. By some, it is believed to be of use in the differentiation of hemorrhagic from other forms of intraocular extravasation.

SUBJECTIVE DETERMINATION OF SENSORY SYMPTOMS.

Passing to the recognition of the next most important series of symptoms,—the subjective sensory,—the observer will at once encounter what at first sight seems the easiest and the least troublesome to obtain. Owing to these facts, the various procedures are so loosely sought for, and the different results are so imperfectly expressed, that a brief though complete detail of the most important of the methods is necessary. First in the list, is the determination of central vision for form.

To accomplish this properly, test-letters are to be employed. The best are based upon the fact that as the smallest angle of distinct vision for a normal eye is equivalent to one minute in width, the exact circular area produced by any pencil of light at increasing distances increases in just such proportion,—in other words, the greater the distance, the greater the area of the one-minute angle must be. In consequence, therefore, every object to be seen distinctly under the angle of minimum visibility, as it is called, must embrace the one-minute area at its equivalent distance. Thus, a letter whose strokes repre-

sent a width of one minute at one metre's distance from the eye, must be double the size to be properly seen at two metres' distance, etc.

These letters, known as optotypi or test-types, are so arranged in sequential order of size, that fractional values of the degree of visual acuity can be readily obtained. To do this correctly, the card is to be suspended upon a well-lighted wall in such a way that the patient has his back to the source of light, and his eyes on a level with the smallest type that is intended to be seen at the chosen distance. One eye should be tried at a time. Care should be taken that the fellow eye is secured from participation in vision by a bandage or a shade. Preferably, the vision of the supposed weaker organ is to be tried first. All the examinations should be made both with the vision uncorrected, and when it is corrected by appropriate lenses.

If, as is preferred by some, artificial illumination be desired, the source of light should be shaded from the patient by an appropriate shade. Should the test-types be ruled to decimal divisions, as they are in the writer's series, the patient is to be placed at five metres' distance from the card. Should he be able to correctly call the letters in the five-diopter line of type at the five metres' distance, his vision is said to be normal. The way this is expressed is in the form of a fraction, using the number of metres employed as the numerator, and the size of the type seen as the denominator: thus, $\frac{5}{5}$ or $\frac{5}{V}$, signifying

$\frac{1}{1}$ vision. If the smallest line of type seen at five metres' distance is the ten-diopter line (that is, what a normal eye can recognize at ten metres' distance), the fraction would read $\frac{5}{10}$, denoting $\frac{1}{2}$ vision. If the forty-diopter line be the smallest type that can be seen at five metres' distance, the fractional value would be one-eighth, as specified by $\frac{5}{40}$. Should it be necessary to bring the patient nearer to the card to see the forty-diopter line of type, the actual distance necessary to bring him to, should be used as a numerator with the 40 as the denominator. Thus, if the new distance be two metres away from the card, the fractional value would read $\frac{2}{40}$, stating that the patient had but one-twentieth of normal vision. If vision be still more defective than can be obtained by the cards, the patient should be made to count the number of fingers that the observer raises and constantly varies; the first essay being made at five metres' distance with the patient's back to the source of light. If vision be still lower, the patient should be made to gaze at a single source of definitely-graded illumination in a darkened room. The farthest distance that the light can be recognized is to be noted as "Light perception at —— metres." If vision be still more defective, the patient is to be brought directly up to the source of illumination and wheeled around so that he faces it. A strong convex lens is then to be held directly in front of the eye, and varying strengths of concentrated light are to be brought to play upon the organ at different

angles and meridians. If the patient fails to recognize any difference, and if he cannot tell when the eye is shaded and when it is exposed, it is probable that he cannot see at all, and the result should be noted with the word "Blind."

In all of this work it must be definitely understood that, dependent upon the patient's occupation and trained mode of employment of his eyes, there is a marked difference of practical value between the real visual equivalent and the necessary functional one.

In many instances, it is of value to study what is known as direct vision for color. To effect this easily and properly, sheets of gauged color squares, similar in size to those of the test-types, or contrivances intended to expose definite areas of colors, are to be employed.

The average area to be exposed for the recognition of a few of the most important colors used at five metres' distance is $2\frac{2}{8}$ millimetres exposure for red; $8\frac{8}{16}$ millimetres for blue; $10\frac{9}{16}$ millimetres for green; and $22\frac{9}{16}$ millimetres for violet. Cards with these quotients arranged at five-diopter differences in size can be made and used in the same way for ordinary routine use as test-types. In all of these tests, just as in those for the determination of central vision for form, note should be made whether any manifest refractive error has been corrected or not.

In all cases, especially where there is any suspicion of subnormal color-perception, more careful testing becomes necessary. The easiest

and most comprehensible method is that with the color yarns of Holmgren. Three large skeins,—light green, purple, and red,—known as "test-skeins," are to be separated from a bundle of smaller pure and confusion skeins, which have been promiscuously thrown upon a large flat table. The patient is first requested to match the green, then the purple, and lastly the red skein as near as possible, without naming the colors. If any abnormality in the color-sense be present, it will soon evidence itself by the choices that the patient makes. Holmgren says that if the first two tests show a decrease of the color-sense, the last can be omitted.

An easier and more accurate method, and one that is less expensive as to material and to time, is that almost daily pursued by the writer. In this test, there are but twenty-three skeins, eighteen of which are match-skeins, and the remaining five are test-skeins. The five test-skeins are pure green, pure red, rose, pure blue, and pure yellow. One or two choices among the match-skeins are to be made for each of the principal tests. Where absolute accuracy as to the degree of the color-sense is not necessary, the first three tests only need be employed. Each skein is designated by a mark that can be understood by the educated examiner, and also, just as with the test-type, is made intelligible to the whole ophthalmic world. Each skein is so dyed that its color-equivalent is absolutely fixed, and all of the match-skeins are of the same relative intensity, thus preventing the patient from judging a tint by differences of shading,—a power that such subjects possess to a remarkable degree.

In many cases of hemicrania, where the patients are intelligent (and, fortunately for the observer, this is the class of subjects in whom this series of phenomena is most often found), much information can be gotten as to the character and the position of the disorder by close questioning as to the direction of movement of paresthetic and anesthetic areas, both in their onsets and disappearances. Study of the coloration and the configuration of the phosphenes, the order of the visible expressions of the attacks, etc., are all of value.

In contradistinction to the plans for the determination of direct vision for form and color, those for the proper recognition of peripheral or indirect vision should also be studied. The art of obtaining such answers is known as perimetry. The procedure can be effected in three different ways, all having the one principle of a fixed point upon which the patient must gaze whilst a peripheral object is being brought into view. The easiest, and the way that the observer will most frequently be brought into contact with in the bedroom, is, where there is not any special form of apparatus. Here the patient can be made to gaze steadily at one of the observer's uplifted fingers, held at about thirty centimetres from his eye. This done, the observer moves a small color-slip or his own upraised finger-tip inward in various directions towards the fixation-object. This plan is of frequent use where rough and ready tests for the mere determination of gross changes in the field of vision are desired.

The next most useful method is that with a ruled black-board which

has been gauged into some definite form, as, for instance, into concentric circles of five-degree differences of separation, or squares of seven and a half centimetres each.

In the centre of the board there is a cross which serves as a fixation-point. Definitely-sized areas of squares or circles of various colors, fastened on long black rods, are then to be gradually moved from the periphery of the board in towards the central point until the color is properly named. The moment that this is done, a chalk-mark—preferably the initial letter of the color employed—is to be made on the board at the point where the color has been correctly designated. All the marks for the same color are to be connected to one another by lines. Transcripts upon proportionately ruled miniature board-blanks can then be made for future reference. One eye is to be tried at a time, always choosing the more defective one first. The other is to be carefully excluded by a turn or two of a roller bandage or a handkerchief. The board should be placed in a good light and at such an angle that the patient's head and body do not cast any shadow upon it. The physiological blind spot should always be searched for, and its position and size are to be accurately noted. Areas of dimmed and blind spots, or scotomata, as they are called, are to be carefully sought for, especially for the colors red and green. This can be done by moving the little color squares or circles over the entire field area. If blind spots are determined, they should be noted in their respective positions upon the blanks.

The third plan, which is extremely valuable when careful scientific study with the fewest loop-holes for error is necessary, is that where some form of the so-called perimeter is employed. The plan is practically the same as in the other two methods, differing merely in the technique that is necessary for the peculiar mechanism at hand. Some of the best forms of perimeters have self-registering apparatuses into which the little register-blanks can be slipped.

In all of this work, the color areas should be frequently changed, tried at various distances from the eye, under varying grades of external stimuli, and substituted for one another in numerous ways.

Should vision be so low that it becomes merely quantitative, and no definite form can be recognized, the field of light-projection, as it is termed, should be mapped out. This can be accomplished in the same manner as with form and color, except that here the fixation-object is made by having a point of strong light-stimulus, such as a candle-flame. The movable object to register the periphery and the scotomatous areas of the field, should be some form of equally strong light-stimulus. The registries are to be made in the same manner as in the other methods, except that here the notes are designative of "candle field" or "quantitative field for light." If possible, graduated beams of light should be used. Another good plan to accomplish the same purpose is to place the patient in the ordinary ophthalmoscopic position, and have him gaze directly ahead. The unused eye should be carefully covered. A beam of light from a concave, or if weaker stimuli be de-

sired, a plane mirror, should be flashed upon the exposed eye from various peripheral points whilst the patient is made to gaze directly ahead. The varying positions of the light are then to be named without allowing the patient to move the eye away from the fixing point. A rough field of light-projection, which is often of incalculable value in many cases of marked nerve-disease, is thus otained.

In addition to the above methods for the subjective determination of the conditions of the sensory portions of the visual apparatus, there are several other plans which are of importance in the recognition of central and peripheral nerve-disease. These, which are frequently omitted from routine ocular examination, are combined in the study of the sensibility of the superficial portions of the organ and its *adnexa*. For this purpose, esthesiometers of various kinds, with specially adapted points for the cornea, can be used to determine sensibility. Wisps of cotton, carefully twisted and coiled upon the corneal surface without touching the lid-edges, may be employed to study the sensibility of this membrane. Local thermometry on and around the anterior face of the eye, can frequently be used to great advantage in the ready recognition of atrophic and degenerate areas from peripheral nerve-disease. Again, if local inflammation be present, pressure with the finger-tips upon or over the affected parts, may often evoke its presence by evidences of tenderness and pain.

OBJECTIVE STUDY OF MOTOR CONDITIONS.

Leaving the methods for the recognition of the sensory disturbances, the observer is brought to what at first sight seems one of the easiest portions of the examination,—that is, the objective study of the motor conditions of the visual apparatus. The muscular movements, however, are so varied in monocular and binocular fixation, and the association of nerve action is so complex in the different physiological acts of the two organs, that the examiner must be mentally well equipped to fully understand the significance of what to the uninitiated may appear to be an indeterminate commingling of movement and action.

Most important are the procedures for the determination of iris movement. The comparative sizes and shapes of the pupils should first be gauged, the former being accomplished by one of the many forms of pupillometer, and the latter by the use of a twelve- to sixteen-diopter convex lens in the sight-hole of an ophthalmoscope. Should the pupil be round, as it seldom is, the horizontal width should be carefully estimated in millimetre lengths. If the pupil be oval, the lengths of the long and short axes should be determined, and the degree of direction of the long axis should be noted. These determinations are to be made during both monocular and binocular exposure, whilst the eyes are gazing directly ahead at a distance, and whilst they are fixed upon some near object, situated at about thirty-five

centimetres' distance from the patient's face. This should be done both immediately in front of the singly-exposed organ and on the median line when both eyes are simultaneously exposed. The patient should be made to face a window or some other source of diffuse daylight. If artificial light be employed, a ground glass shade over the source of illumination will be conducive to better results.

The significance of the size of the pupil itself, although frequently unlike in the two eyes of the same subject, may often be taken advantage of for diagnostic purposes. For example, in myopia it is, by reason of relaxation of accommodation and consequent want of impulse of the sphincter muscle of the iris, as a rule, larger than ordinary. It is also large in most of the various forms of so-called amblyopia and amaurosis. In sympathetic irritation, as may be found in the earlier stages of aneurismal pressure on the nerve, it is large. In paralysis of the third nerve, in glaucoma, cerebral compression, neuroses of functional type, peripheral irritations, it generally becomes dilated. Local application and internal administration of certain drugs, ordinarily known as mydriatics, cause it; moreover, it must be remembered that it is larger in childhood and in youth than it is in adult life and in old age. On the contrary, it is small in hypermetropia. Especially is this so in cases where the patient is continuously using the eyes for close work. In retinal hyperesthesia, in meningeal inflammation, in cerebral irritation, and in certain stages of convulsive seizures, it becomes contracted. It lessens in size during the local and

general action of certain drugs popularly known as myotics. Decrease of the area is an almost certain accompaniment of increasing age. Frequently, as is so often seen in the early stages of posterior spinal sclerosis and general paralysis of the insane, it will be found to assume all manner of bizarre shapes and irregularities of size.

All of these conditions should be noted most carefully.

For the better differentiation of pathological or artificial pupillary disturbances, some one of the numerous mydriatic and myotic agents, such as cocaine, atropine, eserine, etc., can, at times, be employed to advantage.

Having thus roughly determined the equilibrium of the iris series of muscles, the actions of the sphincter muscles of these membranes are next to be studied. As these movements are associated ones, the procedures for their determination must be made under definite conditions. The first and the most important impulse or reflex act is that known as iris-response to light stimulus thrown upon the retina. To study it properly, the patient is made to face some source of diffuse daylight or artificial illumination. He is then to be directed to keep both eyes open and to gaze directly ahead into space. The two organs are then to be covered and alternately exposed to the entering light stimulus until surety is made that there is muscular response or not. If there be any response, it will evidence itself by a more or less complete contraction of a portion or of the entire pupillary area upon exposure of the organ to the source of light. Frequently, in neuroses of degen-

erative type, a series of slowly-decreasing secondary clonicisms may be noticed. These can be best studied by a magnifying lens which has been preferably placed behind the sight-hole of an ophthalmoscope.

The next so-called pupillary reflex act, or better, iris reflex act, to study, is that existing between the ciliary and the iris muscles. Either of these muscles, as can be determined experimentally, contracts its fibres when its fellow is brought into play. When the reflex movement of the iris, producing pupillary contraction, is brought into action by the contraction of the ciliary muscle so as to allow the lens to increase its power of focussing for near vision, the impulse is known as pupillary response to accommodation. To determine whether this reflex motion is in proper working order, one eye is to be covered from use and the other is first made to gaze directly ahead at a distance. When the pupil of the gazing eye has become comparatively fixed in size, an object, such as the finger-tip or a pencil-point, is to be quickly placed at about thirty-five centimetres in front of the exposed eye, and the patient is requested to look directly at the object. If the reflex be in proper working order, the pupil will immediately contract, to dilate when the fixation-object is removed and the eye is made to regaze into space.

A third pupillary response (better, iris response) is where the two eyes are made to accommodate synchronously upon a near object, situated upon the median line. Here, in addition to the relationship of impulse between the ciliary and the iris muscles, there is another factor, known as simultaneous contraction of the internal recti mus-

cles, added. This compound reflex act, which is ordinarily, though improperly, known as the pupillary reaction to convergence,[1] is obtained in exactly the same way as it was during the previous method, except that here the fixation object is situated upon the median line and both eyes are coetaneously exposed.

A fourth response is that in which the pupil dilates when the skin of the back of the neck is pinched. By some it is known as Parrot's sign, and is said to be present in some cases of meningeal inflammation.

All of these examinations should be repeated frequently, often,—taking care in many cases to totally withdraw any form of stimulus from the eyes by temporary bandaging of both eyes,—until certainty of result can be vouchsafed. This cannot be too strongly insisted upon, as nowhere in all of the methods of ocular precision, when the reflexes are carefully or properly studied, can so much information be gained as to deep-seated nerve and vascular disorder of motor type as in these most delicate and evanescent tests.

One of the most important methods of diagnosis is that known as the hemianopic iris inaction sign, or what is popularly known as the Wernicke sign. Here, by the study of the peculiarities of movement of the iris in certain types of hemianopsia, much localizing data can be had as to the position of intracranial mischief. As is well known, the reflex arc for iris movement, when light stimulus is thrown upon the

[1] It would be more fitting to say iris reaction to convergence, as the pupil, being a void, cannot have a reaction.

retina, extends back along the in-going optic nerve-fibres, until when about in mid-brain it associates with the out-going motor nerves of the iris. This, as has been proven anatomically, takes place before the position of the corpora quadrigemina has been reached. This being so, it is certain that, should some break occur within this reflex sensory-motor loop back of the optic nerves themselves,—that is, in the optic chiasm or in the optic tracts,—the want of proper physiological act to any appropriate external stimulus would immediately manifest itself by a failure of response of iris movement, should light stimulus be thrown through the pupil upon the retina. Knowing these facts, so here in hemianopsia, or, in fact, any related field defect, should the lesion be situated in the chiasm or optic tracts anterior to the corpora quadrigemina, the iris muscle will fail to respond when light stimulus is carefully thrown upon the non-receiving portions of the retina.

To produce the symptom satisfactorily, many plans have been urged. In the writer's experience, the easiest and most practical method consists in simply having the patient placed in the ordinary ophthalmoscopic position, except that the source of light is so situated that the rays will come from over his head. One eye should be tried at a time, it being made to gaze straight ahead into a darkened space. The fellow eye is to be excluded from the entrance of all rays of light into it. The observer, standing in front of the patient, is to faintly illuminate the iris that he wishes to study by means of a piece of plain looking-glass such as is employed in the fundus-reflex test. This can

be done by some permanent arrangement of mirror or by holding a glass in the hand. An ordinary concave ophthalmoscopic mirror is to be held in the other hand and a narrow beam of concentrated light is to be thrown upon the pupil from the periphery of the blind area of the field of vision. This beam is then slowly moved in towards the position of the line of fixation. If the sign be present, there will not be any iris movement until the edge of the retained field area has been reached. At this point, an immediate pupillary contraction will take place. This contraction will persist as long as the light stimulus is kept within the persistent field area. Should the lesion be situated posterior to the corpora quadrigemina, pupillary contraction will ensue, even though the stimulus be presented from the blind portion of the visual field, thus showing that the motor-sensory arc is untouched and unharmed.

Another sign, known as the Knies pupil-symptom, is well worth searching for. It consists in a hemianopic inaction without a hemianopic field-defect, and shows that there is some localized disturbance in the different pupillary reflex path between the third-nerve nucleus of one side and its related tract. In some cases of grave nerve-disease, especially where there is coexistent pupillary dilatation, and no answers can be obtained from the patient, much valuable data as to the condition of the ciliary muscle can be objectively obtained by the so-called catoptric test. As is well known, if a small beam of extraneous light be allowed to fall very obliquely upon the pupillary area, and this

area be properly magnified and looked at, three images of the beam will be plainly seen. These images, in their order of succession, are formed upon the anterior convex surface of the cornea, the anterior convex surface of the lens, and the inner concave surface of the posterior portion of the lens. The first two images are large and upright, whilst the third image is small and inverted. In the act of accommodation, which necessarily means a contraction of the ciliary muscle, the convexity of the lens increases. This increase in the strength of the lens shows itself by a separation and a change in comparative size of the lenticular reflexes. The lenticular reflex, which is the second reflex seen in the test, becomes larger and slightly moves anteriorly. The posterior lenticular reflex, which is the third reflex of the test, becomes smaller and markedly recedes posteriorly.

At times, when the pupil is small and when it is impossible to properly study the catoptric images, the plain mirror can be employed to advantage to determine the degree and the amount of accommodative action of the ciliary muscle. If, whilst the instrument is being used to study the play of the movements of the lights and shadows in the fundus-reflex test, it be gradually approached to the patient's eye, there will be a point that is dependent upon the degree of accommodative power possessed by the organ, at which the movements of the reflexes will be reversed. This point, measured from the anterior surface of the eye, will determine both that there is ciliary muscle action and its degree of power.

The objective study of the equilibrium, and the determination of the visible motions of the extrinsic muscles of the two eyes, next demand attention. In many instances, principally in the incipient and in the irritative stages of nerve-disease, the recognition of minor degrees of disturbances of these muscles is extremely difficult. Hidden from view, associated in the most complex way in their normal actions, and so readily compensated for among themselves in their faults, their peculiarities of balance and the disturbances of their action are much less readily recognized upon mere inspection than the peculiarities of their related interior groupings.

Often, however, a quick observer may notice abnormalities of facial expression, and take advantage of peculiar movements of the head and trunk muscles when certain ocular motions are attempted. Should the patient complain of double vision, one eye will often be found unable to fix upon some object held at about occupation distance (such as reading or sewing) upon the median line. The clinical demonstration of this sign, which can be very readily determined by alternately excluding one of the eyes whilst its fellow is made to gaze at an object, such as a pen-point, held directly ahead of the patient at about thirty-five centimetres' distance, is ordinarily known as the method by exclusion. If desired, the degree of deviation of the faulty eye can be estimated by the aid of a strabismometer, held in front of each eye. This experiment can be repeated in any meridian of the field of vision that may be desired. In fact, if due allowance for situation be taken, it

may be tried in any position of muscle equilibrium that may seem to be desirable. Again, the degree of rotation effected by the globe and the character of the movement when the eye is made to follow the upraised finger, is of the greatest importance as an objective test. If there be an irritated or hypertrophied muscle, the movement of the eyeball in the direction of the muscle will be greater than the movement of the opposite eyeball in the direction of the corresponding muscle. Should there be a paresis of the affected muscle, the movement of the globe to which it is attached will be limited in the direction of the pull of the muscle. An excellent routine in the determination of these conditions is to first consider the monocular movements in the horizontal meridian. This is to be followed by a study of the movements in the vertical meridian and at oblique angles. These observations should be repeated with the two eyes simultaneously, taking care in all instances to add the associated physiologic movements, as, for instance, the two interni in maximum convergence and the related external and internal groupings in conjugate deviation. If these tests be properly and intelligently conducted, they will often, especially if the observer be quick and certain in his finger movements, bring to light many minor discrepancies of both peripheral and central type that otherwise might escape attention.

Watch should be made for slight ataxic movements during extreme action of the suspected muscle. Here the eyeball seems to successively recede several times back along its excursional route and regain

for a second or two its point of limitation of movement, before being able to accurately and steadfastly fix upon the observer's upraised finger.

In all of this work, it should be remembered that the degree of movement in different directions of any two or more groups of muscles is greatly at variance, not only in respect to the individual strength of the muscles, but also as to the physiological acts that are being required of the muscle-grouping at the time of action. For instance, the lateral movements of the globes, both separately and combinedly, are far greater than the vertical, whilst the utmost degree of the movement of the two interni during the effort for binocular convergence is far less, especially in hypermetropes and in old subjects, than it is when these muscles are separately employed in association with the externi during conjugate deviation. Again, the observer should remember that errors of refraction may so mask the apparent results of the most carefully performed work that, at times, the most bizarre and seemingly incongruous findings may be obtained. For this reason, therefore, no tests for muscle-balance and motion, unless so marked that they cannot be mistaken by the merest novice, should ever be undertaken until all or as much refractive error as possible has been expunged.

If the observer be an adept in the art of ophthalmoscopy, and knows so well how to handle the instrument that it offers no inconvenience in any way, or even if its use in this particular connection is repeated sufficiently often until all technique has been thoroughly

mastered, the presence of muscular deviation may often be objectively decided. To do such work properly, the patient is to be seated in the ordinary ophthalmoscopic position. The light is to be placed directly over and back of his head. The observer is to stand directly in front of the patient and to face him. The patient should now be made to gaze steadily at the sight-hole of the instrument or the forehead of the observer. The observer is to gaze alternately at the two eyes of the patient and study the relative situations of the bright light-reflex upon the patient's corneæ. The feeblest nystagmic motions may ofttimes be brought to view by recourse to one of these methods. If the mirror be not at hand, a candle-flame so shaded from the observer that it does not interfere with the sight of the patient's corneæ, may be substituted. This latter plan, although somewhat more difficult and necessitative of more practice, has several times served the writer at the bedside.

A spasmodic action of the superior elevator muscle of the upper lid, known as Abadie's sign, may, at times, be distinguished in cases of Basedow's disease. Lessening of the palpebral fissure, described by Jacobson as sympathetic ptosis and probably due to paralysis of the sympathetic, may appear during the course of posterior spinal sclerosis. Imperfect action of the orbicularis muscle with pupillary movements dependent upon a minor degree of facial palsy, which has been called attention to by Berger as appearing in the same disease, should be sought for in suspected cases.

At times, in exophthalmic goitre, the upper lids lag when the

eyes are made to direct their gaze downward. This, known as the "von Gräfe sign," has, in the hands of the writer, been the easiest recognized, whilst the patient is made to lie flat upon his back, with his head slightly elevated and inclined forward upon a firm, hard pillow. While the patient is in this position, he should be made to gaze with his two eyes at the observer's finger-tip, which is to be held at about seventy centimetres directly above the patient's face. The observer is then to slowly move his finger in a curvilinear direction towards the patient's breast. If the sign be present, the upper lids will lag, whilst the eyeballs will follow the finger. Dalrymple's sign, or Stellwag's symptom, which consists in an abnormal widening of the fissure between the lids, can often be seen in the same disease.

In some instances, a valuable clinical guide as to the degree of smoothness and evenness of the movements of the extra-ocular muscles through their tendinous sheaths and coverings, can be obtained by the employment of auscultation. The writer has sometimes felt that he has thus added an additional diagnostic factor in so-called muscular paralyses that later have been found to have been mere mechanical impediments to muscle-action. This he has several times observed in cases of rheumatism and gout.

Subjective Study of Motor Conditions.

The last grouping of studies of the motor series of ocular symptoms (the subjective motor) is in reality the most vague, and frequently the

most confusing. Here, not only must the answers depend upon the patient's assertions, which often are the sequences of incomprehensible questions to his uneducated mind, but frequently, especially in the seriously ill and the mentally unfit, the apparent results are useless and valueless. When properly obtained, however, and fortunately, as a rule, in subjects whose disease is in its very incipiency, the results are most valuable. Brief training of the patient with a couple of the procedures, and explanation of what is to be expected in a few of the easiest methods, before any attempts at examination are made, have, in the writer's experience, saved much subsequent useless labor upon his part, and given answers that have been eminently satisfactory.

Commencing with the easiest and the most easily comprehended, the plan for the determination of the disturbances of the extra-ocular muscular groupings will be taken first. The muscles should be tested both when they are used to fix the eyes upon near and when they are made to have them gaze upon distant objects. In every instance, care must be taken to note the circumstances under which the test is being performed. Taking the study of the deviations where the eyes are gazing at a distance first, the simplest and easiest plan to render any disturbance apparent, and one which can be accomplished without the employment of any delicate or complicate apparatus, is to have the patient placed in a darkened room. He should then be made to gaze at a minute point of light, situated at about five metres' distance from his eyes and upon a level with them. A ten-degree prism, base up or

down, is next to be placed before one of his eyes. Preferably, as a routine, the left eye should be the one chosen. The relative positions of the false light thus produced and the true one are then to be ascertained. For example, if the prism be placed base up before the left eye, the false image thus produced and seen by the left eye, will be thrown below the true light. Should the inferiorly-situated false light be also thrown to the right, there is, by reason of the left false light having been crossed over to the right of the true right light, a condition known as crossed or heteronymous diplopia. This shows that the patient has either an enervation of the left internus muscle or a spasmodic contraction of the right externus muscle. So, similarly, with any series of muscles, the position of the false image as compared with the true one will always give immediate and almost certain answer as to the character of the fault and the determination of the muscle that is disturbed. These obtained, the degree of apparent variation can then be readily determined by the superposition of increasing strengths of correcting prisms with their apices placed towards the supposed affected muscles.

Should the false light, when the prism is placed either base up or down before one eye, appear upon the side towards the eye before which the prism is placed, the double vision, or diplopia, as it is termed, would then be known as homonymous. If, under the same circumstances, the two lights be situated immediately in vertical line, there is said to be orthophoria or perfect binocular equilibrium in that meridian.

If desired, a gauged card can be substituted for the correcting prisms, and the amount of apparent deviation can be readily designated by the patient. To assist in the determination of the relative positions of the two images, the true one can be made to appear as "red" to the patient by placing a piece of plain red glass before the eye that has not any prism before it, thus more readily differentiating it from the false one that has been produced by the prism-bearing eye.

In vertical deviation obtained by horizontally-placed prisms, the prism-strengths must be necessarily greatly increased. This is so, by reason of the preponderant powers of the lateral muscle-groupings over the vertical muscles to overcome stronger prisms. In this series of experiments, the faulty findings are to be estimated by vertically-placed correcting prisms. If, during such experiments, a tendency for vertical deviation of one of the visual lines be found, hyperphoria is said to exist.

Another rough and ready test for the determination of muscle-balance that is peculiarly applicable to the sick-room is what is known by Duane as the parallax-test. After having placed the patient and a distant light upon a proper level, he is to be requested to alternately expose the two eyes whilst he endeavors to steadfastly gaze at the light. If muscle-balance exists, the right and the left image of the light will not apparently undergo any movement. If any muscular deviation be present, the images of the lights will appear to jump into a new position the moment that the covered eye is exposed. If desired,

the degree of muscle disturbance can be easily estimated in this test by means of correcting prisms.

With properly-constructed apparatus, the tests for the determination of muscle-balance become more beautiful and more certain. Commencing with the simplest,—the glass-rod test of Maddox,—much important data, especially from previously instructed and intelligent subjects, can be obtained. The contrivance essentially consists of one or more short cylinders of clear glass that distort the image of the light into one or more lines that are situated at right angles to the direction of the placing of the rod. The image of the lines is so different in outline and shape from the untransformed image of the light as seen with the opposite naked eye, that it cannot be confounded or fused with the undisturbed image of the fellow eye. Consequently, if no impulse for fusion exists, the muscles of each eye will assume their individual state of equilibrium. This is immediately shown by the relative positions of the projections of the two series of images. Should any deviation exist, its angle and its degree can easily be estimated, just as in the previous test, by the addition of the prismatic strengths that are necessary to superimpose the lines exactly upon the untransformed candle-flame.

If the patient can be seen at a consultation room, where more delicate contrivances can be employed, some one of the better grade phorometers and revolving prisms, such as Prince's, Risley's, Jackson's, or Stevens's, may be used. Where greater delicacy or where scientific

accuracy is necessary, some more complex and more expensive contrivance, such as Brayton's optomyometer, may become useful.

The above-mentioned simpler tests, when used in their various forms by an accurate observer, can hardly fail to elicit adequate data as to almost all forms of muscle discrepancy, after sufficient repetition and due explanation have been given to the patient. In many of the grosser and more marked cases, the mere superposition of a plain red glass before one of the eyes will be all that is necessary to study the kind and the degree of diplopia.

In numerous instances, the writer has found that it is a good plan to estimate one faulty meridian, as, for example, the horizontal, and then, after this has been corrected, to search for any disturbance in the opposite meridian and to estimate this. By this plan, the combined correction frequently evinces a less difference of necessary strengths in each of the two meridians than would be found were they to be separately estimated. This should always be remembered, as it is a plan of procedure that may be of the utmost etiological importance and even of subsequent therapeutic value in special cases under study.

Another method that may at times be adopted, is to estimate the amount of prism-deviation that the different extra-ocular muscles can overcome. This is done by having the patient look at a distant light with his two eyes, and then substituting stronger and stronger prisms before one eye with their apices pointed towards the muscle of that eye which is desired to be studied, until double vision is complained of.

As a rough guide, the internal rectus muscles are said to generally overcome about forty to fifty degrees of prism strength; the external rectus muscles about eight degrees; the inferior rectus muscles about four degrees; and the superior rectus muscles about three degrees.

In all cases, the subjective determination of the degree of the power of the ciliary muscle, thus evidencing the amount of consequent lenticular action, is necessary. To do this properly, one eye should be tried at a time. It is always best to commence with the supposed more affected one. A series of small test-words are to be first approximated so closely to the patient's face that he cannot recognize any of the type. By now slowly moving the card away from the eye, the distance of the point of the first correct naming of the letters or spelling of the smallest words upon the card away from the eye is to be noted in centimetres. This distance or measurement gives the near point, or punctum proximum (p.p.), as it is termed. This represents the utmost strength of the accommodative or focussing apparatus of the eye, and shows the amount of action of the ciliary muscle. After this has been registered, the card of type is to be removed beyond the limit of distinct vision for the same size of letters that has been used to obtain the near point. The letters are then to be slowly approached towards the patient's eye until another similarly-sized word or combination of letters is correctly read. This gives the farthest point, or the punctum remotum (p.r.). The two series of findings are to be noted in the following manner: for example, "Acc. (accommodation) = type 0.50

D (the size of one series of letters), 20–35 c.m. (centimetres)." Where presbyopia is supposed to exist, or where there are high and extreme degrees of ametropia, the superposition of correcting lenses, taking care to specify them in the notings, should be employed to enable the patient to read the test-words.

In addition to these four varieties of procedures for the determination of the motor and sensory symptoms of the visual apparatus, the observer should never fail to obtain a clear and a concise history of any pre-existing and present ocular symptoms. A brief record of the gross objective condition of the organ should be noted. The deeply-seated and the more superficial vascularity of the sclera and overlying conjunctiva should be studied. Fatty degeneration areas around the periphery of the cornea should be searched for. The state of the lacrymal apparatus should be determined. Marks of inflammatory thickenings, and the degree of intra-ocular tension, should both be recorded.

If to these the relative prominence of the eyes be gauged, and palpation and auscultation be practised for the detection of orbital bruit, the work will be more complete. At times, it must be remembered that patients may either intentionally or unwittingly feign certain ocular symptoms. The determination of the truth or falsity of their assertions can be accomplished by experiments and procedures which are intended to either actually deceive or confuse the patient. Plans of all kinds, dependent upon the ingenuity of the examiner, can be tried for this class of subjects.

In parting, the writer can give no better advice to the reader than to study every ocular symptom that may appear of importance to the elucidation of the cause of any related neural disturbance. The examiner should understand that it is the entire grouping of the ocular conditions that alone can furnish proper data. This must be done repeatedly and sufficiently often to allow an understanding of the course taken by the symptoms, and to formulate some generalization as to their significance. In fact, if in all of his work the reader should constantly employ the most careful and painstaking technique, and exercise proper judgment as to the meaning of the findings, he will soon realize that the reputation and certainty of his results will far more than repay him for his trouble and his care.

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